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Effects of Level Fanya Juu and Fanya Chin Structures on Grain Yield of Maize in Moisture Stress Areas of Daro Labu District, West Hararghe Zone, Ethiopia

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Abstract
The experiment was conducted during 2011 and 2012 cropping seasons in moisture stress area of Daro Labu district in Sororo peasant association, Western Hararghe Zone. It was conducted to evaluate the effect of level Fanya Juu and Fanya Chin conservation structures on grain yield of maize and to increase farmer's level of awareness and skills on utilizing the technologies for improving production. The treatments were level Fanya Juu, level Fanya Chin and farmer's practice used as a control with test crop maize (melkasa-4 variety) arranged in Randomized Complete Block Design on three farms as replications. The data on yield (Qt ha^{-1}), stand count at harvest, number of cobs per plot and maturity date were collected. At the first year, 2011 cropping season, the statistical analysis reveals that there was a significant difference ($p<0.05$) among the treatments on maize grain yield (Qt ha^{-1}), but no significant variation in stand count at harvest, number of cobs and maturity date . On the second year, 2012 cropping season there was no significant difference among treatments on maize grain yield, stand count at harvest, number of cobs and also maturity date. Therefore, when farmers practice without conservation structure is compared to both structures, the level Fanya Juu and Fanya Chin were better by yield (i.e. yield advantage varied from 7.5-87% over farmers' practice). Thus this study confirmed that, both soil and water conservation structures decrease soil erosion and conserve soil moisture during two years of cropping season. Therefore this physical conservation structures could be recommended for further scale up in moisture stress areas of Daro Labu district and similar agro ecologies.
Keywords*:* Fanya chin, Fanya juu, Farmers practice, Maize, Moisture stress, Number of cobs, Yield,

1. Introduction

Ethiopian agriculture is mainly rain fed agriculture with only about 5% of the total arable land under irrigation. Although the average annual rainfall is about 848mm with a maximum over 2000mm, it is highly erratic and often falls intensively (Michael and Teklu, 2006; Regassa et al., 2006). Despite the high average annual rainfall 848mm and favorable environmental variables for agriculture, the performance of rain fed crop production is very poor which attributed to high temporal and spatial variations in rainfall, wide spread nutrient deficiencies and improper soil, water and crop management (Tamirie, 1986; Heluf and Yohannes, 2002; Michael and Teklu, 2006).

The rates of annual loss of soil due to erosion for Ethiopia vary from almost zero on lowland grasslands to over 200 tons ha^{-1} $year^{-1}$ on steep slopes of the highlands cultivated with erosion promoting crops such as maize or sorghum (Getachew, 1998).

Soil and water conservation is called upon to alleviate both the problems of erosion and drought which are symptoms of two different extremes of rainfall conditions. As rainfall erosivity, soil erodibility and landform are inherent properties of climate, soil and land, respectively, only little can be done to modify their effects appreciably. Therefore, control of soil erosion and runoff water depends on judicious soil and crop management practices (Hudson, 1977; Lal, 1977a, b). The practice of judicial water conservation undoubtedly plays a significant role in increasing agricultural production in arid, semi arid and sub-humid areas where agriculture is hampered by periodic droughts and low soil fertility (Tamirie, 1986; Heluf, 1989; Heluf and Yohannes, 2002).

The efficiency of the physical soil and water conservation techniques depends on the soil type, climate, the crop grown and the cropping methods. Among physical soil and water conservation measures, level Fanya Juu and Fanya Chin are some. The term Fanya Juu and Fanya Chin originate from Swahili which literally means 'make upwards' and 'make downwards' respectively, each term referring to the way these are constructed. Fanya Juu is constructed by digging a trench and throwing the soil uphill to form an embankment and can be developed to bench terrace if enough soil moves down slope and lodges above the embankment. Similarly, Fanya Chin is constructed by digging a trench and throwing the soil downhill to form an embankment (Amanuel et al., 2002).

However, despite the significance of the problems of soil erosion and low soil fertility in the Ethiopian semi arid and arid areas, research aimed at generating soil and water conservation techniques and farming practices that reduce soil erosion and harvest rain water for use by plants, on cultivated lands in the country, is inadequate. Today Ethiopia is entering an era of physical and economic water scarcity due to increase in population pressure, degradation of the natural environment, increase in livestock pressure, the increase in cost of supply and increase in demand for other uses such as industries, lack of efficient and effective water institutions that insures equal allocation of the nominally accessible water among users (Moges, 2006).

On the other hand, the countries human population is growing at an alarming rate, which necessitates increased food and fiber production to meet the corresponding growing demand. This is possible only through efficient use of the natural resource base with which the country is endowed. As rainwater is the prime factor that largely determines the level of rainfed agricultural production, its improved efficiency can substantially augment the countries food security endeavors (Michael and Teklu, 2006). Many analysts believe future increases in food supplies and economic prosperity for the rural poor of Ethiopia will mainly come from improved agricultural soil and water management. In light of which researchers, policy makers, NGOs and farmers are increasingly experimenting with and promoting various innovative agricultural water management technologies and practices (Regassa et al., 2006).

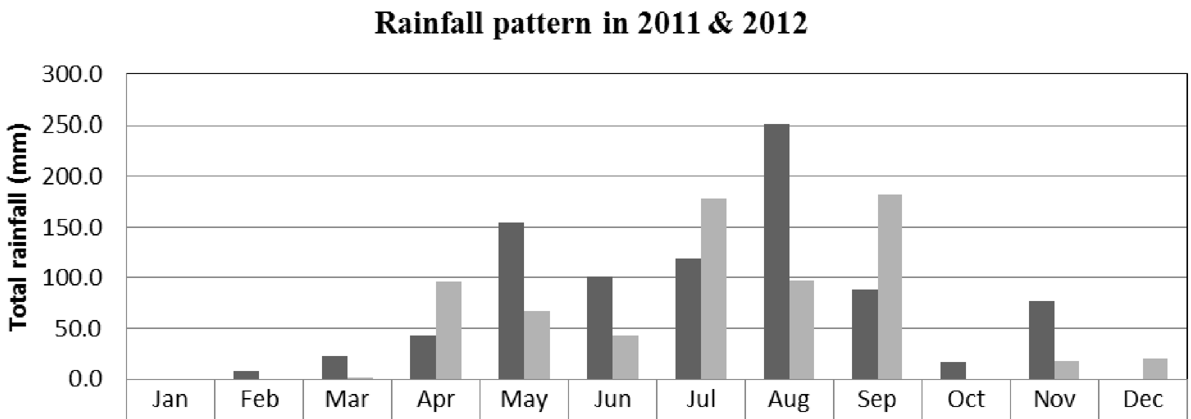
In Daro Labu district, where this project intended to be done, moisture stress is the primary problem, which highly constrains the productivity of smallholder farmers particularly the midland and lowland parts of the districts (priority problem raised in REFLAC-Research Extension Farmers Linkage Advisory Council meeting). Extreme dry spells and recurrent drought is usual. Late start, early finish and little in amount is the main characteristics of rainfall in the study areas (Eshetu et al., 2010). Due to this crops fail at vegetative stages before seed setting, Livestock lost in the absence of feed and water due to drought prevails. As a result, the population living in the districts is food insecure and is under aid by Safety Net programs, United Nations World Food Program and other Non Governmental Organizations. To cope with prevailing moisture stress so that ensure food security of the region, promoting and evaluating different soil and water conservation technologies is necessary. Therefore the study was initiated with the objectives of evaluating the effects of level Fanya Juu and Fanya Chin conservation structure on grain yield of maize in moisture stress areas of Daro Labu district as well as enhancing farmers' level of awareness towards utilizing these technologies.

2. Materials and Methods

2.1 Description of study area:

The field experiment was conducted in Western Hararghe zone of Oromia Regional State, in Daro Labu district. It is located 434 km to the east of Addis Ababa and 115 km from Chiro (Zonal Capital) to the south on a gravel road that connects to Arsi and Bale Zones. Its latitudinal and longitudinal positions are $40^{0}19.114$ North and $08^{0}35.589$ East respectively. The area has bimodal type of rain fall distribution with annual rainfall ranging from 900-1300mm with average annual rainfall of 1094mm and ambient temperature of the district varies from 14 to $26^{o}C$ with an average of $20^{o}C$ (summarized from Mechara Metrological Station (2009-2014)).

The nature of rain fall is very erratic and causing tremendous erosion. The altitude range for Daro Labu is 1350 to 2450 m.a.s.l with area coverage of 434,280ha and the predominant production system in the district is mixed crop-livestock production with peculiar sub-systems. The crops grown in the area includes Maize, Sorghum and Finger millet and also fruit crops like Banana and Mango. The major soil type of the area is nitisol and its texture is sandy loam clay which is reddish in color. (Report on farming system of Daro Labu and Boke districts, Mechara Agricultural Research Center ,unpublished). Figure 1 shows the actual rainfall pattern during the trial period (2011-2012) which was taken from nearby meteorological station (i.e. Mechara station which is found at about 10kms from Sororo Peasant Association where the trial was conducted).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	0.0	8.0	22.7	43.2	154.2	100.9	118.6	252.0	88.1	16.9	76.9	0.0
2012	0.0	0.0	0.2	95.6	67.3	43.3	178.3	97.7	182.4	0.0	18.3	19.7

Figure 1: Monthly rainfall pattern in 2011 & 2012 at Mechara meteorological station

2.2 Experimental design, data collection and analysis

The study was conducted in moisture stress areas of Daro Labu district during a period of 2011-2012 cropping season for testing the effect of level Fanya Juu and Fanya Chin on grain yield of maize (Mekasa-4 maize variety). One peasant association was selected from Daro Labu district where moisture stress is the primary problem. Three farmers were selected from peasant association based on willingness who participates on construction of the structures. Level Fanya Juu and Fanya Chin was constructed with length of 10m, depth of basin 60-70cm, top width 1m which is tied at 1m between basins on 5% slope of land. However level Fanya Juu was constructed by digging a trench and throwing the soil uphill to form an embankment and Fanya chin was constructed by digging a trench and throwing the soil downhill to form an embankment. Melkasa-4 maize variety was used as a test crops sown with plot size of 10m x 10m and recommended inorganic fertilizer rate and spacing of 75x25cm were used. Farmers practice without soil and water conservation structures used as a control. The numbers of farmers were considered as replications. Data on yield (quintal ha^{-1}) were collected from experimental plots and then converted to hectare, number of maize plants were counted at harvest (stand count at harvest), number of cobs per plot were counted and maturity date were collected. Then the collected data were subjected to analysis of variance using SAS statistical software and means were separated using Least Significant Difference (LSD) test. Finally, the yield advantage were calculated by the difference of yield obtained from the constructed structure and farmers practice (without structure) and then divided by the yield obtained from the farmers practices and finally multiplied by 100 to put in a percentage.

$$\text{yield advantage} = \frac{(\text{yield obtained from structure - yield obtained from farmers practice})}{\text{yield obtained from farmers practice}} * 100$$

3. Results and discussion

There was significant differences ($p<0.05$) between treatment on yield (quintal ha^{-1}), but number of cobs, stand count at harvest and days of maturity were not significantly different ($P>0.05$) for the first year of cropping seasons (2011) Table 1. There was Significant variation ($P<0.05$) among treatments on stand count at harvest and number of cobs during 2012 cropping season. However, there was no significance variation ($p>0.05$) among treatments on days of maturity and yield (Table 2).

Table 1: Mean yield of maize variety (quintal ha^{-1}), stand count at harvest (STCH) and number of cobs per plot (NCpt) during 2011 cropping season.

Treatment	Mean values of parameters during 2011 cropping season				
	STCH	NCpt	Yield (Qt/ha)	Days maturity	Yield advantage (%)
Level Fanya Juu	572	661	52.7	112.00	7.5
Level Fanya Chin	594	657	59.2	111.00	20.8
Control	649	658	49	111.00	
Mean	**605**	**658.1**	**53.64**	111.77	
LSD 0.05	175.3	118.25	5.1529	2.2031	
CV (%)	12.78	7.92	4.270345	0.869	

Table 2: Mean yield of maize variety (quintal ha^{-1}), stand count at harvest (STCH) & number of cobs per plot (NCpt) during 2012 cropping season

Treatment	Mean values of parameters during 2012 cropping season				
	STCH	NCpt	Yield (Qt/ha)	Days to maturity	Yield advantage (%)
Level Fanya Juu	665	655	54.09	115	87
Level Fanya Chin	709	694	41.9	115	45
Control	357	343	28.9	113	
Mean	**577**	**564**	**41.64**	114.222	
LSD 0.05	169.03	127.6	26.93	1.7722	
CV (%)	12.9	9.9	28.5	0.684	

Even if the analysis of variance did not show the significance difference, the maximum number of maize plant at harvest were recorded for maize sown without structures over maize sown with structures during 2011 cropping season (Table 1). However, their seeds were aborted due to moisture stress from maize sown in farmers practice. Also, number of cobs per plot were recorded from maize sown in the level Fanya Juu as compared to level Fanya Chin and farmers practice. The maximum yield of maize (59.2 quintal ha^{-1}), (52.7 quintal ha^{-1}) were recorded feom the level Fanya chin and level Fanya Juu respectively and the minimum maize yield of (49 quintal ha^{-1}) was noted from the local check. The yield advantages of 20.8% and 7.5% were obtained from the level Fanya Chin and level Fanya Juu respectively over the local check during 2011 cropping season (Table 1). During 2012 cropping season, maximum number of maize counted at harvest (709 and 665) and number of cobs (694 and 655) were recorded from level Fanya Chin and level Fanya Juu respectively. The maximum maize yields of 54.09 quintal ha^{-1} and 41.9 quintal ha^{-1} were recorded from the level Fanya Juu and level Fanya Chin respectively. The yield advantages of 87% and 45% were obtained from the level Fanya Juu and level Fanya Chin respectively as compared to the local check (Table 2).

According to the above finding, the soil and water conservation structures had resulted in greater yield than the local check. There is an extensive literature reporting trials of Fanya juu and fanya chin in eastern and southern African countries. The principle of level Fanya Juu is to retain rainfall and hence, increase soil moisture, water availability to plants, and increase the efficiency of fertilizer application if any (Lakew et al., 2005). In addition to this, some of the reports indicate that the Fanya Juu technique has successfully increased resultant yields (Motsi et al., 2004; Tenge et al., 2005). Abay (2011) also showed that, construction of soil conservation structures like Fanya Juu, crops yields are significantly increased by 22% on some farms within one year and greater than 50% after three years although the increment differs from farmer to farmer as the management of soil by different farmers are not the same (Lal, 1977b). This study also shows that yield advantage obtained from maize sown in level Fanya Juu and Fanya Chin increased from year to year. Also Fanya Juu terrace increased crop yield by 25% (Liniger et al., 2011). Thus the study verified that, among the treatments considered in the study, sowing in the Level Fanya Juu and Fanya Chin produced higher yield when compared with farmers' practice. Similarly in Kenya district, Machakos, crop yields increased by 50% or by 400 kg ha^{-1} through the use of Fanya Juu terraces (Eriksson, 1992). The yield reduction during 2012 was due to reduction in rainfall (Figures 1 and 2). The result also revealed the importance of moisture conservation structures with decreasing rainfall that the yield advantage increased to maximum of 85% over the farmers practice in 2012 (Table 2).

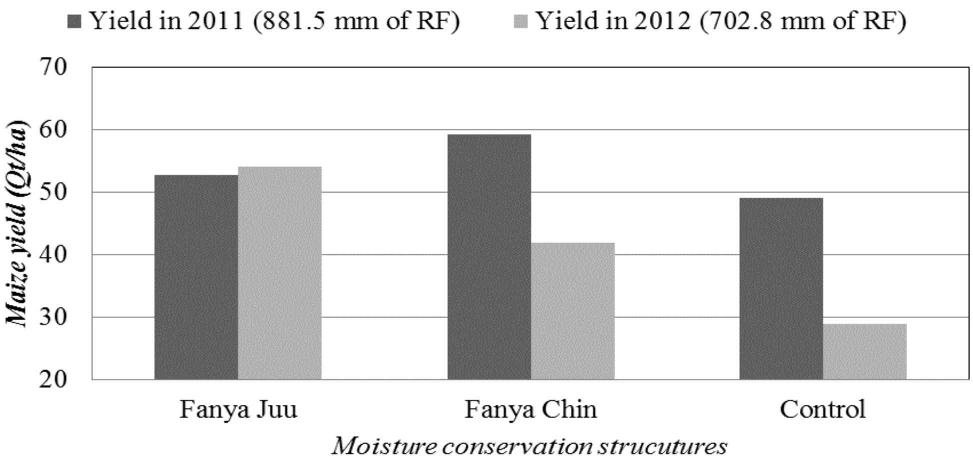


Figure 2: Relationship of moisture conservation structure and yield of Maize in 2011 and 2012 cropping season.

4. Conclusion and Recommendation

Although, it was not supported by soil sample analysis may be soil moisture and soil type however depending up on parameters collected from crops sown in different structures, there is no sufficient evidence to say there is significance difference between treatments with regards to yield during two years of practice. However the adoption of this moisture conservation structure improves crop production and increase the yield advantage as soil moisture/rainfall decrease.

Analysis of result reveals that, both structures level Fanya Juu and Fanya Chin were better than farmers practice with regards to yield , number of maize plants counted at harvest, number of cobs per plot. The structures were also preserved soil and moisture during two years practice. Depending on these results (i.e. yield improvement, considered conserving soil moisture and reducing soil erosion) both structures were recommended with early maturing and drought resistant maize variety or other annual crops to be further scaled up in moisture stress areas of Daro Labu district and other similar agro ecology.

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